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FINAL REPORT ON PROJECT NO. C-53,

JULY, 1942, THROUGH JUNE, 1943

CORRELATION OF SOLAR AND GEOMAGNETIC OBSERVATIONS WITH CONDITIONS OF THE IONOSPHERE

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September 18, 1943

Contract No. OEMsr-594

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Contract expired June 30, 1943

Copy No. 41 of 150 copies
printed September 30, 1943

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CORRELATION OF SOLAR AND GEOMAGNETIC OBSERVATIONS WITH CONDITIONS OF THE IONOSPHERE

(Under Contract No. OEMsr-594)

Abstract

Project No. C-53 for the study of correlation of solar and geomagnetic observations with conditions of the ionosphere was continued during July, 1942, through June, 1943, at the Department of Terrestrial Magnetism, Carnegie Institution of Washington, with the cooperation of American-operated solar, magnetic, and ionospheric observatories. The cosmic data thus assembled were analyzed (1) to increase the understanding of solar, geomagnetic, and ionospheric relationships and (2) to improve the technique of short-term forecasting of ionospheric disturbances.

Electron-density in the ionospheric regions affecting long-distance radio communication has continued to diminish as the minimum of the 11-year cycle of activity approaches. Some magnetic and ionospheric disturbances occurred, and the isolation of solar regions responsible for terrestrial disturbances was simplified by the reduced solar activity. Solar corona of high intensity, and observed activity in flocculi on the disk were found apparently the most promising criteria for anticipation of magnetic disturbances. The beginning of the new sunspot-cycle indicates an early increase of solar, magnetic, and ionospheric activity. Ionospheric absorption, sporadic E-region ionization, aurora, and magnetic bays and character-figures were found to be related in fairly definite ways, in most cases approximating direct proportionality. Methods of obtaining accurate visual records of magnetic phenomena were developed and one visually recording instrument was constructed.

Useful operational material regarding ionospheric disturbances affecting radio circuits were supplied to the Army and Navy, both directly and subsequently through the Interservice Wave Propagation Laboratory of the Joint Communications Board. The project is being continued by the Carnegie Institution of Washington under a non-profit contract directly with the armed forces.

Introduction

The project for "Correlation of solar and geomagnetic phenomena with conditions of the ionosphere" was initiated on July 1, 1942, at the Department of Terrestrial Magnetism, Carnegie Institution of Washington. A general relationship between solar activity and various terrestrial phenomena affecting radio communication has been recognized for a number of years, but the technique of identifying the connections was not completely satisfactory. This project, then, was (1) to organize the reporting of solar, magnetic, ionospheric, and related data, (2) to analyze the material, and (3) to develop methods or relationships of immediate military value.

Organization of program

Weekly reports of magnetic activity (three-hour character-figures) were received from the stations of the United States Coast and Geodetic Survey at Cheltenham (Maryland), Tucson (Arizona), Sitka (Alaska), Honolulu (Hawaii), and San Juan (Puerto Rico), and from the magnetic observatories of the Department of Terrestrial Magnetism of the Carnegie Institution of Washington at Watheroo (Western Australia), Huancayo (Peru), and College (Alaska). Daily and special reports of magnetic activity were furnished by the Cheltenham Magnetic Observatory.

Ionospheric records and summaries, obtained with multifrequency equipment at the three observatories of the Department of Terrestrial Magnetism, were available each month. Ratings of commercial conditions of radio communication were furnished at intervals by the Bell Telephone Laboratories and by RCA Communications. Ionospheric data and disturbance-ratings prepared by the Interservice Wave Propagation Laboratory at the National Bureau of Standards were obtained regularly.

Solar observations included: (1) Drawings of sunspots and observations of their polarities from the Mount Wilson Observatory; (2) sunspot-data and copies of daily photographs from the United States Naval Observatory; (3) drawings of calcium flocculi and prominences with estimates of activity from the McMath-Hulbert Observatory; (4) observations of solar corona and prominences from the Climax (Colorado) station of the Harvard College Observatory; and (5) spectrohelioscopic reports from the Whitin Observatory, Wellesley College. (Views of the first four observatories are given in Figures 1 to 4.) In the twelve-month period, observations were made at the full-time cooperating solar observatories as follows: McMath-Hulbert, 249 days; Climax, 216 days; Mount Wilson, 335 days; and United States Naval, 273 days.

Weekly and special forecasts of ionospheric conditions were prepared and distributed by this office to the Armed Services until October, 1942, and since then by the Interservice Radio Propagation Laboratory of the Joint Communications Board with the aid of data and analyses of this project.

Results of investigations

Magnetic activity--The course of magnetic activity during the report-year is shown in Figure 5, which is arranged to show recurrence-tendencies of disturbed and quiet periods. The American magnetic character-figure is used, being the average character of magnetic records obtained at each of eight American-operated magnetic observatories (Cheltenham, Tucson, Sitka, Honolulu, San Juan, Watheroo, Huancayo, and College). The tendency for magnetic disturbances to recur at intervals of about 27 days was very pronounced with the smaller storms during this period of minimum solar activity. One storm-sequence started on July 14-16 and reached its maximum on October 26-31 with the severest storm of the report-year. It later divided into two disturbances spaced several days apart and was traced into March, 1943. The disturbed period, August 16-27, recurred in September and again in October. Another disturbed period, centered about April 3, repeated itself in the succeeding three cycles.

During the year there was a high percentage of disturbed days, but no really large storms. The previous twelve-month period had three storms of greater intensity than the one of October 26, 1942, but there were 14 per cent more days appreciably disturbed in 1942-43 than in 1941-42. Thus, rather than severe magnetic storms with their spectacular effects, the past year was characterized by mild disturbances during a relatively high percentage of the time.

Geomagnetic and solar observations--A general comparison of geomagnetic and solar phenomena during July 1, 1942, to June 30, 1943, is given in Figure 6. Discussions of some of the observations are given elsewhere in this report. Illustrated are: (1) American magnetic character-figure, C_A; (2) relative sunspot-number, R; (3) area, S, of sunspots in the central zone; (4) area, F, of flocculi in the central zone; (5) average total area, P, of prominences referred to central meridian of date; (6) average intensity, C, of the green coronal line referred to the central meridian; and (7) transmission-disturbance figures, TD. Although the solar data are not homogeneous because of differences in observing conditions, each curve is reasonably consistent within itself. The graphs are similar at many times but differ conspicuously in detail.

The popular belief that magnetic and ionospheric storms may be "blamed" on the sunspots is, of course, entirely wrong. Disturbances have been associated with various types of solar activity but no single method has yet been developed which will consistently account for terrestrial disturbances. However, there is adequate evidence to confirm the theory that all such disturbances originate at the Sun and that the radiation does not travel with the speed of light. Many instances of nearly simultaneous humps in most of the curves are evident, the best being at about November 2, 1942. Others are August 23, September 16, November 26, December 26, 1942; March 23, April 6, April 21, and May 17, 1943. There are, however, as many more cases where magnetic disturbances had no obvious solar cause shown in the diagram, and cases where solar activity had no magnetic counterpart. Special characteristics of the several types of solar observations are examined in following sections.

Magnetic activity at meridian passage of large sunspots--It has been shown by a statistical analysis of solar and magnetic data extending over many years that large magnetic disturbances tend to occur one day after the meridian passage of large sunspots. During the report-period there were no large magnetic storms but several large sunspots. An inspection of the magnetic activity at time of meridian passage of the large sunspots shows that the tendency was not operative in this interval.

The two days before and four days after the meridian passage of a sunspot, seven days in all, were associated with the meridian passage of the spot. For the five spots with maximum area

greater than 700 millionths of the Sun's visible hemisphere, the average magnetic character-figure of these days was 20 per cent less than the average character-figure of all days in the year. Furthermore, 20 per cent fewer slightly disturbed days and 40 per cent fewer moderately disturbed days were included in the selection than would be expected by the average frequency of occurrence of these classes of days. The average character-figure at the meridian passage of eleven slightly smaller spots, with maximum area more than 300 but less than 700 millionths, was the same as that of all days. Slightly disturbed days were ten per cent more frequent and moderately disturbed days 20 per cent less frequent in this selection than the average occurrence-frequency of such days in the whole year. Clearly magnetic activity and the meridian passage of large sunspots did not correlate in this period.

For the position of sunspots at the time of maximum of the nine largest disturbances of the period, on the other hand, it is found that in four cases there were spots of area greater than 300 millionths on the face of the Sun, but in each instance more than three days from the central meridian. In seven cases there was a spot, sometimes vanishingly small, within two days of the meridian. Thus during the 12-month period the magnetically disturbed days did not correspond preferentially with the meridian passage of large sunspots. Earlier conclusions, that size of spot alone is not a sound basis for predicting magnetic activity, are therefore confirmed.

Progress of solar-activity cycle and beginning of new sunspot-cycle--Magnetic activity and properties of the ionosphere parallel roughly the 11-year solar-activity cycle. The last minimum in that cycle occurred in 1933 and another minimum is due between 1943 and 1945. It is of considerable practical value to the field of communications to foretell the minimum and hence the time when an increase in solar and geomagnetic activity may be expected. Progress of the activity-cycle is shown in Figure 7, where half-yearly averages of sunspot-numbers are compared with the magnetic index u (smoothed), and with average maximum critical frequency of the F_2-layer (09^h, 75° west meridian time) at Huancayo. The parallelism of the curves for critical frequency, which is proportional to the square-root of electron-density, and sunspot-number is much closer than that of either factor with the magnetic-index curve. This suggests the preference of ionospheric measurements as direct indicators of terrestrial effects of sunspot-activity. It is evident that magnetic activity has declined less rapidly and regularly than might be expected from the trend of solar activity. The recent solar and magnetic data are not exactly comparable to the earlier years, because of restrictions on international exchange of data caused by the war, but the trend of the activity-cycle is continuous and shows that the time of minimum activity is approaching.

The trough of solar activity is usually defined by the minimum of Zürich relative sunspot-numbers. The average number at minimum in past cycles has been four, and has never been more than ten. For 1942 the average number was 30, and so far in 1943 it is approximately 22. Over 13 cycles minimum activity followed the preceding maximum by 6.7 years and the preceding minimum by 11.5 years, although both were subject to large deviations. About six years have passed since the last maximum and ten since the last minimum. These signs all point to a time of minimum sunspot-activity one or two years in the future.

The beginning of a new sunspot-cycle occurs with the appearance of spots in high heliographic latitudes, which may be distinguished from sunspots of the old cycle by the reversal of magnetic polarities. The new cycle usually appears within six months of the minimum of solar activity and after spots of the old cycle have become infrequent. On May 16, 1943, a bipolar spot broke out in 40° south latitude and observations of polarities by the Mount Wilson Observatory established it as the first spot of the new cycle. Figure 8, taken at the United States Naval Observatory on May 17, 1943, shows this new spot near the southwest limb and also a spot of the old cycle near the central meridian. Several other small spots belonging to the new cycle have subsequently been observed.

The remarkable feature of this event is that it occurred when there were still many active low-latitude spots. In 1933, when the first spot of the diminishing cycle appeared, no spots were observed on the Sun on 234 days during the year. In the report-year, however, there were only 17 spotless days. Commencement of the new cycle at this time suggests that there may be a larger overlapping of the two cycles than usual. As a consequence, the minimum of solar activity may not be as low as usual and the geomagnetic activity in the next few years may become more pronounced.

Magnetic disturbances associated with activity on disk--Observations made at the McMath-Hulbert Observatory include an estimation of the activity of flocculus groups based chiefly on observed short-period structural changes. Geomagnetic disturbance averages greater than normal when floccular activity is reported, especially in a region near the central meridian. As the Sun is not under continual observation, the record of active floccular regions is not complete. It is significant, however, that observation of solar activity of this kind coincides so often with magnetic disturbance.

Ninety-two cases of floccular activity were reported and may be divided into three classes according to position on the Sun. These are: (1) The central zone, -26° to +26° meridian distance; (2) the zone east of the central zone; and (3) the zone west of the central zone. Average magnetic character-figure and the occurrence-frequency of moderately disturbed days were computed for days on which activity was reported and the first day following. The ratio of these to the mean of the whole year shows the tendency toward disturbance on days when solar activity of this sort was observed as follows:

Zone	East		Central		West	
Days after activity	0	1	0	1	0	1
Magnetic character (normal = 1.0)	1.3	1.2	1.3	1.0	1.2	0.9
Occurrence-frequency of moderately disturbed days (normal = 1.0)	1.4	1.4	1.6	1.0	1.4	0.8

It is evident that days on which floccular activity occurred were considerably more disturbed than the average, especially in the central zone. Since the day following the reported activity is relatively less disturbed, it may be inferred that the disturbing agency does not outlive the floccular activity by as much as a day and that the agency is terrestrially effective coincident with the observation. It is interesting, considering the large number of cases reported, that such a clear association of floccular activity with magnetic disturbance is obtained. Such activity represents high probability of chromospheric eruption, a phenomenon which is infrequently observed.

Magnetic activity following observations of significant coronal intensities--It is generally supposed that geomagnetic and ionospheric disturbances are of solar origin. Since the corona is the outermost observable region of the Sun, the radiation must pass through it and may leave evidence of the traverse. This may be a brightening of the corona over the active region, a lengthening of the coronal arc, or visible extension of the corona into space. There is, then, good possibility that suitable observations of the corona will identify the presence of solar activity that may have terrestrial effect. It may be assumed that the corona is relatively stable such that observations made at the east limb are representative of conditions when the same area approaches the central meridian--about seven days later. Similarly the coronal observations on the west limb may be representative of solar activity at the central meridian--about seven days earlier. Alternatively, an active solar region may affect a large part of the Sun so that the corona at the limb would be representative of conditions on the visible disk as well.

Daily observations of the corona made at the Climax (Colorado) Station of the Harvard College Observatory include maximum intensity of the green coronal line (λ 5303Å) on either limb. The days with abnormal coronal intensities (more than 1.6 arbitrary units July 1 to December 31, 1942, and more than 1.0 arbitrary units January 1 to June 30, 1943) are shown in Figure 9. Observations are arranged on a 27-day (solar-rotation-period) cycle. Significant east-limb observations are shown by the shading of the top half of each square. Significant west-limb data referred back 14 days are shown by shading the lower half of each square. Blank spaces indicate a normal intensity or no observation. Figure 10 shows the days in the same interval that were magnetically disturbed, also arranged in 27-day cycles.

A comparison of Figure 9 with Figure 10 suggests a general relationship between the phenomena. In each there are four conspicuously shaded areas, illustrating recurrences of high coronal intensities and of magnetic disturbances with repeated solar rotations. Further, the shaded areas in Figure 10 are systematically displaced to the right of those in Figure 9, suggesting a small interval between observation of an abnormal east-limb corona and incidence of the magnetic disturbance.

Abnormal coronal intensity on the east limb was observed on 53 days between July 2, 1942, and June 7, 1943. Average magnetic character-figures were computed for each of the two days preceding and 14 days following the significant observations. The deviation in per cent of this average character-figure from the mean is shown in Figure 11, which traces the average course of magnetic activity following observations of large east-limb coronal intensities. A disturbance begins the day after the observation of intense corona, reaches its maximum on the third or fourth day, and continues with decreasing intensity through the seventh day.

Since the average character-figures are disproportionately affected by large magnetic storms, it is desirable to use the occurrence-frequency of disturbed days as an alternative measure of average magnetic activity. This will counteract the possible dominating effect of a small minority of relatively large storms. The deviation of the frequency of occurrence of "above-average disturbed" and of "significantly-disturbed" days from the mean occurrence-frequency of such days throughout the period is also shown in Figure 11. The curves show a tendency for maximum disturbance to occur on the fourth day, with disturbance greater than average over the entire period from the second through the seventh day.

Corona of high intensity is often observed for several days in succession. Consequently, magnetic activity associated with periods of extended intense corona will appear several times in the above analysis. It is doubtful whether a period of magnetic disturbance lasts proportionately longer when high coronal intensity is observed for many days in a row. Therefore, when abnormal intensities were observed on consecutive days, the day of maximum intensity was selected and the above procedure again followed. Figure 12 shows the average magnetic activity following 24 such maximum east-limb coronal intensities. In this case the graphs show a tendency for maximum disturbance to occur on the third, fourth, and fifth days and the average degree of disturbance is greater than before.

This analysis suggests that large east-limb coronal intensities are followed two to seven days later by magnetic disturbances. The greatest likelihood of disturbance apparently is three, four, and five days after maximum coronal intensity.

Waldmeier, at Zürich, has found that abnormal intensity of the corona could be associated with magnetic storms in ten out of fifteen cases of high intensity east-limb corona in 1940-41, and that the seventh and eighth days after the coronal observation were the most disturbed. This would be expected if corpuscular emission from the central zone of the Sun were responsible for magnetic disturbance. It is striking that no tendency is shown in the present analysis for magnetic disturbance to occur seven and eight days after the observation. Systematic coronal observations so far are insufficient to formulate a definite relationship with magnetic activity but the information is finding useful application in the coordinated program.

A separate method for investigating solar-geomagnetic relationships has been developed by W. O. Roberts of the Climax (Colorado) Station of the Harvard College Observatory. This consists of converting daily estimates of red and green coronal intensities to a linear scale and then determining the total daily change in intensity on both limbs without regard to sign. This becomes the coronal "change-number" for that day. Large changes were shown to precede by about two days the principal geomagnetic disturbances of the first half of the report-year. The method has not been subjected to a statistical analysis because observational material is not adequate. It demonstrates, however, another potentially valuable way of treating coronal data in the development of solar-geomagnetic relationships.

Sporadic E-region ionization* and signal fade-out at College, Alaska--The general ionospheric effects observed during magnetic storms are a reduction in critical frequency and an increase in absorption. In cases of severe disturbances which are common in high latitudes, complete signal fade-out or intense sporadic E-region ionization are observed. The diurnal variations of the frequency of occurrence of sporadic E and of signal fade-out are similar and are exactly out of phase. In northern regions, at least, the summation of the two is, in general, directly related to magnetic character. The average per cent of the time that these ionospheric phenomena were observed at College, Alaska, in 1942 during each gradation of magnetic disturbance as measured by the three-hourly K index is shown in Figure 13A.

The lowest degree of sporadic E-region ionization used in this analysis corresponds to a penetration-frequency at vertical incidence of four Mc/sec. The frequency-range of signal fade-outs included in the analysis extended to the critical frequency of the E-layer and higher. Figure 13A shows that fade-outs and sporadic E becomes more frequent the larger the disturbance, although the slope of the curve decreases for magnetic K-index greater than four.

*By sporadic E-region ionization we refer to the blanketing type which often masks off other ionospheric regions. This is characterized by a number of multiple reflections indicating a high reflection-coefficient. It should not be confused with the weak and highly erratic "border" reflections which are observed at frequencies higher than the normal E-region penetration-frequencies. The "blanketing" type is undoubtedly highly effective in radio wave-propagation but the usefulness of the "border" type is considered to be questionable.

Figure 13B shows that in daylight hours signal fade-outs were the common ionospheric effect during magnetic disturbance. The maximum frequency of occurrence was indicated at index K = 4. The curve for very large K-indices is dotted since too few observations are available to establish its reality. Sporadic E-region ionization is relatively rare during the day at College and shows no significant relationship to magnetic character. The daytime relationship of signal fade-out to magnetic character is closely duplicated by sporadic E at night. Figure 13C shows a maximum at index K = 4 followed by a slight decline in occurrence-frequency of sporadic E during more disturbed periods. Signal fade-outs in the night hours are infrequent even during periods of large magnetic disturbance. Some characteristics of the night absorption are discussed in next section.

This study indicates that the two ionospheric phenomena--intense sporadic E and signal fade-out--are systematically associated with magnetic disturbance, night and day, respectively. The diurnal differentiation may be attributed either to a thermal change in the heights of equal molecular density with consequent production of ions in regions of low mean free path, or to a difference in energy of the solar particles bombarding the day and night hemispheres. As a practical result, the analysis suggests that near the auroral zone, at least, the probability of abnormalcy in the ionospheric conditions reflected by sporadic E-region ionization and high absorption is no smaller for magnetic disturbances with values of index K = 4 than for more severe disturbances.

A high degree of correlation at the College Observatory between occurrence of zenith-aurora and intensity of sporadic E-region ionization was reported by Bramhall and Seaton. The correlation-coefficient for the winter of 1942-43 ranged between 0.8 and 0.9. Of perhaps equal significance, the mean value of sporadic E-region critical frequency with visible zenith-aurora was almost twice that when no such aurora was observed. From the relationship between sporadic E and magnetic activity discussed above, zenith-aurora in high latitudes appears to be an indicator both of ionospheric abnormality and of magnetic disturbance.

<u>Polar radio disturbances during magnetic bays</u>*--Strong absorption of radio waves associated with complete disappearance of all signals is often encountered in polar regions. In particular such radio blackouts are found to occur during magnetic bays--typical magnetic disturbances of short duration which are preceded and followed by generally undisturbed magnetic conditions. These bays are very pronounced near the auroral zone although their magnetic effects extend to equatorial regions.

During every one of 89 significant magnetic bays recorded at College, Alaska, high ionospheric absorption producing partial to complete radio blackouts was observed. The frequency of bays averaged eight a month and they usually occurred between 10^h and 16^h GMT--night at College. They frequently ran in series of two to five days, having a recurrence-interval of close to 24 hours.

The similarity of these blackouts to the well-known daylight fade-outs is marked. Both effects appear to be caused by absorption due to intense ionization of the lower ionosphere. The absorption during daylight has been identified by Dellinger as the result of bursts of solar ultra-violet light while the polar blackouts, so prevalent during all magnetic disturbances, must result from particle bombardment (or equivalent) from the Sun.

<u>Visual recorders of magnetic activity</u>--The close relationships between magnetic and ionospheric disturbances have indicated the need for a visually recording magnetic variometer of simple construction. An instrument of this type would permit immediate assessment of degree of disturbance and an application of the observed correspondence between ionospheric and magnetic phenomena, especially when operated in high latitudes. The onset of a magnetic disturbance is usually recognizable from standard magnetic records before the storm has reached its major phase. However, magnetic recordings are made on photographic paper and the daily traces are not available for inspection until the paper has been processed. This is generally too late for immediate application of established relationships. A visual recording variometer would overcome this difficulty and make possible short-term evaluation of expected local ionospheric disturbances. Practical use of the 24-hour recurrence-tendency of magnetic bays in polar regions is an example of one such possible application.

One type of visual recorder incorporating a sparking device to plot changes in the Earth's field was devised by M. L. Zimmer and R. H. Goff of this Department. A long platinum-tipped pointer attached to the magnet-system of the variometer moves over a metallic plate as the suspended magnet deflects in the Earth's field. At intervals of about one minute a spark from the tip

*Abstracted from Special Report No. 1 of December 31, 1942, by H. W. Wells, under Contracts OEMar-558, OEMsr-594, and NXs-11605.

of the pointer to the metallic plate makes a record on a sheet continuously moving through the spark-gap. Thus a succession of points burned in the paper plots variation of the Earth's field with time.

In a second method a photoelectric cell is made to follow the light-beam reflected from a mirror rigidly fastened to the suspended magnet of a variometer. A pen attached to, or synchronized with, the photocell gives a record in ink of the deflections of the variometer. Any unbalance of light falling on a twin photocell results in a movement of the photocell to a new position seeking a balance. When equal amounts of light fall on both sections of the photocell, the moving pen stops until a change in magnetic field again causes an unbalance. This instrument has attractive remote-recording possibilities. The soundness of principle was demonstrated by an experimental model and further development is contemplated.

Another type of visual recorder utilizes special photographic paper which leaves a trace, immediately visible through a red filter, of deflections of the light-beam from a standard variometer. A standard hydrographic recorder was adapted for use with this equipment. One instrument was completed, tested, and assigned for field-tests shortly after the end of the report-year. A universal variometer of new type was designed by E. H. Vestine of this Department for this visual recorder.

<u>Summary of magnetic observations, College (Alaska) Observatory</u>--Frequent reference has been made in this report to magnetic observations at the College (Alaska) Observatory. These data are of particular importance to correlations of solar, geomagnetic, and ionospheric measurements because of the location in the zone of maximum disturbance. The magnetic program was conducted under a separate contract (NOrd-392) during the report-year and has been incorporated since July 1, 1943, in the combined project for ionospheric, signal intensity, magnetic, and related observations significant to analysis of radio wave-propagation.

The insensitive la Cour variometers and standardization technique were described in "Report on College (Alaska) Observatory, March, 1941, through June, 1942", which was submitted to the National Defense Research Committee on August 15, 1942. Scale-values of the instruments were maintained at 18.2 γ/mm for horizontal intensity (H), 26.5 γ/mm for vertical intensity (Z), and 5'.2/mm for declination (D). All magnetograms were currently scaled for variations in H, Z, and D, for the three-hour gamma-ranges, and for K-indices. The tabulations were forwarded monthly to Washington and summaries of the K-indices were reported weekly by telegraph.

Mean three-hour gamma-ranges (upon which the K-indices are based) are shown for each month in Figure 14A as based on Table 1. The seasonal disturbance-variation with peaks near the equinoxes is characteristic. The mean daily variation of disturbance shown in Figure 14B displays the usual peak shortly before 12^h GMT, corresponding to local magnetic midnight. The same data for 1941-42 are included for purposes of comparison, and an increase of ten per cent in the mean yearly gamma-range in 1942-43 over 1941-42 is shown.

Average diurnal variations in H, Z, and D as shown by the mean hourly departures from the monthly means are given in Tables 2, 3, and 4. Figures 15 and 16 represent the mean diurnal variation in horizontal intensity for each month, and for the year--both for all days and for quiet days. Only horizontal intensity is illustrated because perturbations in that element are usually greatest. In the mean for all days the diurnal-variation curves follow a regular pattern, the minimum between 02^h and 03^h, 150° west meridian time, resulting from magnetic bays associated with increased ionospheric absorption.

Preliminary mean values of the three magnetic elements are given in Table 5 and Figure 17. The most prominent secular change is the decrease in east declination amounting to about 2' per year. There is also a small increase in vertical intensity of about ten gammas per year.

The general characteristics of large magnetic storms at College were determined from a study of the 15 storms each having a daily range in H of approximately 1000 gammas. In the initial phase a small increase in H was usually accompanied by a small increase in Z. The main phase of the storms were characterized by large increases in H with smaller and inconsistent changes in Z. In the subsequent recovery-phase, Z returned to normal somewhat before H. Although these were the general tendencies of large magnetic storms, the scatter of individual storms was large, making uncertain the prediction of the progress of any specific disturbance.

Acknowledgments

The assistance and advice of Dr. J. A. Fleming, Director of the Department of Terrestrial

Magnetism of the Carnegie Institution of Washington, contributed materially to this project. Other members of the staff, who cooperated in providing data and services, were E. H. Bramhall, S. L. Seaton, and E. H. Vestine.

Particular acknowledgment is made the directors and personnel of the several coöperating solar observatories, namely: Dr. R. R. McMath, Dr. O. Mohler, Dr. L. Goldberg, Mr. J. Brodie, and Miss C. Lee of the McMath-Hulbert Observatory; Dr. W. S. Adams and Dr. S. B. Nicholson and their collaborators at the Mount Wilson Observatory; Dr. D. H. Menzel, Dr. W. O. Roberts, and Miss D. Emery of the Climax Station of the Harvard College Observatory; Captain J. F. Hellweg and Mrs. L. T. Day of the United States Naval Observatory; and Dr. J. C. Duncan of the Whitin Observatory. Dr. J. H. Dellinger and F. R. Gracely of the Interservice Radio Propagation Laboratory at the National Bureau of Standards cooperated in many phases of the work.

The regular reports of data on magnetic activity from the United State Coast and Geodetic Survey and of radio-circuit operations from RCA Communications and Bell Telephone Laboratories were found of great value in this project on correlation of solar, geomagnetic, and ionospheric conditions.

Tables 1 to 5 and Figures 1 to 17 follow.

Table 1--Mean monthly three-hour ranges in gammas showing daily variation of magnetic disturbance, College, Alaska, July, 1941, to June, 1943

Month	Three-hour range for GMT interval																	
	1941-42									1942-43								
	00-03	03-06	06-09	09-12	12-15	15-18	18-21	21-24	Mean	00-03	03-06	06-09	09-12	12-15	15-18	18-21	21-24	Mean
	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
July	...	...	...	...	...	...	...	...	...	104	130	180	347	221	142	83	74	157
Aug.	116	130	216	324	258	194	107	99	180	81	137	189	312	261	183	102	68	167
Sep.	98	149	263	346	375	231	150	80	212	105	136	248	536	377	252	101	104	232
Oct.	47	64	137	264	180	170	100	60	128	125	152	269	506	484	430	167	104	279
Nov.	81	128	271	369	292	265	138	76	202	75	92	169	454	376	216	110	71	195
Dec.	60	62	126	254	251	184	111	60	138	52	61	130	267	351	195	79	51	148
Jan.	38	58	90	230	211	154	56	44	110	43	39	124	320	255	194	89	49	139
Feb.	44	65	100	249	217	189	163	54	135	47	71	158	295	210	110	72	41	126
Mar.	126	166	218	521	399	396	225	96	268	61	68	155	302	237	190	87	57	144
Apr.	119	137	271	337	297	265	130	62	202	106	154	250	378	300	174	82	58	188
May	61	89	112	166	120	110	53	46	95	143	178	304	400	268	197	95	76	207
June	73	93	123	177	184	141	74	47	114	100	145	177	326	256	150	69	58	160
Mean	78	104	175	294	253	209	119	66	162	87	114	196	370	300	203	95	68	178

Table 2--Average diurnal variation of magnetic horizontal intensity shown by departures from monthly mean, College, Alaska, July, 1942, to June, 1943

150° West Meridian Time	Year and month												Mean
	1942						1943						
	July	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	
h h	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
	Departures for all days												
00-01	-51.0	-30.3	-130.2	-61.6	-45.2	-32.0	-40.6	-38.5	-47.2	-61.7	-72.6	-66.4	-56.9
01-02	-87.9	-56.6	-110.0	-120.8	-107.0	-88.2	-78.5	-65.7	-54.7	-91.4	-89.5	-87.2	-86.4
02-03	-63.5	-88.5	-70.3	-201.5	-135.0	-124.4	-68.9	-31.6	-75.2	-80.7	-69.7	-103.3	-92.8
03-04	-64.9	-88.9	-78.5	-215.0	-132.2	-126.2	-79.2	-34.2	-55.0	-75.0	-70.0	-61.2	-90.1
04-05	-53.0	-47.1	-80.9	-147.2	-96.2	-91.4	-64.9	-25.0	-40.6	-91.0	-85.8	-54.7	-73.1
05-06	-29.5	-38.4	-59.7	-121.7	-59.3	-28.0	-13.1	-5.5	-69.9	-54.0	-78.5	-37.4	-49.6
06-07	-7.7	-40.8	-44.2	-88.0	-20.0	-20.5	-31.5	-19.9	-21.8	-27.4	-44.1	-21.1	-32.2
07-08	-10.1	-9.7	-10.1	-36.4	-0.5	-9.7	-31.7	-15.0	-6.4	-13.5	-5.7	-7.9	-13.1
08-09	-1.7	-11.9	-2.2	6.2	11.3	18.7	-4.5	-15.8	7.3	1.1	-6.8	2.2	0.3
09-10	-8.4	-15.4	8.0	22.0	14.2	23.4	14.9	-5.5	6.6	2.6	-1.3	4.4	5.5
10-11	-14.1	-12.3	6.9	31.7	25.6	28.5	15.5	1.7	-8.0	2.4	1.7	-0.4	6.6
11-12	-13.2	-5.0	14.0	45.0	27.7	23.8	19.3	2.9	0.2	1.8	4.2	-5.3	9.6
12-13	-9.7	1.3	18.0	57.3	30.4	26.7	18.2	2.9	9.6	2.9	7.2	0.4	13.8
13-14	3.9	12.1	30.6	52.5	27.9	30.2	22.4	2.9	14.9	12.6	12.5	4.8	18.9
14-15	18.4	22.8	43.7	65.8	37.1	31.3	25.2	6.0	20.2	17.8	27.0	13.6	27.4
15-16	29.2	34.6	46.0	78.5	50.6	33.3	32.8	13.2	27.5	37.7	48.6	30.6	38.6
16-17	41.1	39.4	48.6	88.8	51.2	38.8	33.9	21.2	35.7	56.2	77.0	46.3	43.2
17-18	45.3	52.9	64.1	94.9	54.4	43.3	31.7	24.7	37.5	59.8	67.0	75.2	54.3
18-19	58.0	61.8	69.9	102.5	47.8	52.2	33.0	33.6	42.4	67.6	84.0	69.6	60.2
19-20	69.0	64.5	73.2	94.0	51.2	47.2	37.6	45.1	39.3	67.0	80.8	61.8	60.9
20-21	64.6	68.0	70.9	78.7	49.3	49.0	46.3	39.3	47.2	63.7	71.2	59.4	58.9
21-22	61.1	50.9	66.5	60.9	48.2	44.3	47.7	21.8	46.2	68.7	54.3	53.6	52.0
22-23	36.7	30.7	39.3	65.0	51.3	26.9	37.5	25.2	35.1	43.8	2.6	38.9	36.1
23-24	-19.4	4.6	-10.9	50.5	53.1	-1.3	-3.3	17.1	11.6	-12.8	-14.0	-13.8	5.1
	Departures for quiet days												
00-01	18.4	12.1	-17.7	17.8	30.6	-1.6	0.0	-4.0	11.3	6.0	7.7	5.0	7.2
01-02	12.2	6.1	-29.5	-2.9	-37.1	-3.3	-21.8	-0.7	9.1	4.6	0.6	2.6	-5.0
02-03	-2.0	1.5	-22.2	-22.3	-2.5	-1.8	-8.6	-6.9	0.4	-7.5	-0.6	-0.4	-6.1
03-04	-21.3	2.4	-13.1	-1.6	-28.3	-2.7	-2.0	-19.5	-0.7	-11.3	4.4	-6.6	-8.3
04-05	-5.5	-6.4	-21.1	2.4	-43.2	-2.6	-6.2	-9.7	-3.3	-9.9	-10.5	2.0	-9.6
05-06	-7.0	1.3	-29.1	-4.8	-17.5	-4.2	-2.0	1.5	-12.9	0.2	-6.3	8.1	-6.1
06-07	-3.5	3.5	-11.0	-7.5	-14.4	-3.5	-0.2	2.0	-10.6	8.1	4.0	7.2	-2.2
07-08	-3.9	-4.6	1.1	-6.4	-2.7	-0.7	2.6	-1.6	-10.4	7.9	3.7	3.1	-1.0
08-09	-7.0	-10.8	-4.6	-8.0	2.7	1.3	5.8	-2.2	0.0	-0.2	0.4	-4.6	-2.3
09-10	-16.1	-22.6	-8.2	-13.7	-0.4	2.6	2.0	0.2	1.1	-3.8	-6.6	-9.5	-6.2
10-11	-23.7	-24.8	-6.9	-15.7	-0.7	1.5	-0.9	1.1	-4.4	-13.0	-13.1	-16.9	-9.8
11-12	-25.1	-22.8	-4.2	-13.5	-1.6	0.4	-4.4	1.3	-7.7	-15.4	-18.0	-22.6	-11.1
12-13	-25.9	-18.4	-1.1	-7.3	2.7	-1.5	-6.5	0.2	-8.9	-14.5	-22.6	-23.8	-10.6
13-14	-9.4	-11.6	1.3	-3.3	0.4	-4.2	-2.6	-1.8	-11.8	-11.9	-18.4	-22.8	-8.0
14-15	-9.9	-1.3	7.5	-2.6	-0.5	-4.9	1.5	-4.4	-9.5	-5.9	-14.0	-12.1	-4.7
15-16	-8.8	-0.4	8.2	1.1	11.7	0.5	1.6	-3.6	-2.9	-2.6	-7.4	-3.3	-0.5
16-17	5.9	3.5	8.0	1.3	16.7	4.2	2.4	2.7	-1.3	0.5	-5.9	4.8	3.6
17-18	8.6	15.8	14.0	9.0	14.4	4.9	6.7	4.2	1.6	4.8	-2.9	9.5	7.6
18-19	17.4	14.0	17.3	11.9	14.2	4.6	7.3	7.3	3.5	6.8	7.7	13.6	10.5
19-20	18.4	10.7	20.4	8.0	14.4	4.9	4.5	6.4	3.8	10.4	17.1	15.4	11.2
20-21	24.6	10.1	19.8	8.0	15.3	3.7	4.7	3.1	7.1	11.9	26.5	14.1	12.6
21-22	22.9	13.8	27.7	15.9	14.6	2.0	6.4	7.7	12.4	14.1	14.5	16.9	14.1
22-23	22.4	14.5	35.3	17.9	17.6	0.7	4.9	10.8	15.8	11.9	22.2	15.0	15.8
23-24	20.2	14.9	8.4	15.7	21.2	0.7	6.0	4.9	18.7	9.3	16.0	7.2	11.9

Table 3--Average diurnal variation of magnetic vertical intensity shown by departures from monthly mean, College, Alaska, July, 1942, to June, 1943

150° West Meridian Time	Year and month												Mean
	1942						1943						
	July	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	
h h	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	
	Departures for all days												
00-01	-0.8	-10.5	-21.4	0.3	0.6	-8.9	-8.2	-7.4	-0.3	-11.1	3.2	-9.9	-6.2
01-02	10.4	-8.3	-34.4	-7.8	-2.2	-8.9	-27.7	-42.3	-10.3	3.7	-4.0	-16.0	-12.3
02-03	2.7	-7.5	-26.7	29.5	1.4	-5.0	-20.1	-27.1	-14.0	-15.8	-8.8	-19.5	-9.2
03-04	-9.1	-15.8	-16.9	-26.7	-26.7	-18.9	-16.4	-25.8	-20.1	-8.5	-13.3	-33.1	-19.4
04-05	-11.0	-21.4	-10.0	-1.9	-45.4	-35.6	-28.5	-21.0	-22.4	-11.6	-19.7	-6.4	-19.6
05-06	-14.5	-1.9	-15.0	-5.3	-38.1	-36.4	-39.6	-15.3	-21.1	-26.4	-18.4	-6.7	-19.9
06-07	-12.1	-21.6	-22.2	-30.3	-42.5	-31.4	-27.2	-9.7	-39.4	-19.8	-24.2	-19.5	-25.0
07-08	-15.1	-21.6	-23.6	-39.2	-33.1	-35.3	-15.6	-18.4	-20.9	-27.5	-20.8	-14.7	-23.8
08-09	-20.0	-12.8	-15.6	-32.5	-24.2	-28.4	-9.8	-20.0	-13.5	-15.6	-14.6	-12.3	-18.3
09-10	-20.3	-13.6	-6.9	-23.6	-18.2	-19.2	-6.6	-16.3	-9.3	-9.5	-13.0	-8.6	-13.7
10-11	-19.5	-7.8	-1.4	-10.0	-7.0	-9.4	-2.9	-12.6	-6.9	-3.7	-9.3	-4.3	-7.9
11-12	-14.8	0.3	4.7	-3.9	0.8	3.6	2.4	-4.2	-1.6	3.4	-3.5	-2.1	-0.6
12-13	-9.1	9.2	16.4	17.5	12.0	10.8	5.8	3.9	7.7	9.5	6.1	8.0	8.2
13-14	0.5	16.1	20.3	25.0	20.0	15.6	10.3	12.4	3.7	16.1	13.8	12.5	13.8
14-15	12.9	20.3	26.7	27.0	29.8	20.6	16.9	21.3	21.1	21.7	25.6	9.6	21.1
15-16	17.5	25.5	28.6	31.7	25.6	21.1	20.3	23.6	20.9	24.3	26.9	16.3	23.5
16-17	20.0	28.0	28.3	30.6	32.2	22.5	21.9	22.4	22.5	20.6	20.0	18.7	23.9
17-18	22.5	28.9	29.4	29.2	30.3	25.3	20.8	22.4	24.3	19.6	27.7	19.0	24.9
18-19	27.2	27.2	31.7	27.8	24.5	27.8	21.6	24.6	20.9	13.7	14.6	31.0	24.2
19-20	23.0	23.0	34.7	23.6	26.4	31.4	27.2	29.4	27.5	15.3	16.8	25.1	25.3
20-21	14.3	16.4	6.7	1.1	30.9	31.4	29.6	26.8	28.4	16.7	4.5	16.0	18.6
21-22	10.4	-6.9	7.2	-12.5	14.5	23.1	16.9	31.3	11.9	2.9	-1.6	4.8	8.5
22-23	-5.2	-20.6	-11.1	-27.3	-9.4	15.0	10.0	11.8	-0.8	-4.8	-16.0	-6.7	-5.4
23-24	-11.0	-28.0	-30.3	-26.7	-5.0	-8.3	-2.6	-8.7	-8.7	-13.5	6.4	0.5	-11.3
	Departures for quiet days												
00-01	-2.8	-13.6	-11.4	-8.1	-0.3	1.9	7.9	-7.1	5.3	-2.9	-2.9	-5.6	-3.3
01-02	-3.8	-18.3	-18.6	-8.1	-17.5	-7.2	-3.7	-11.8	-0.3	-7.1	-10.4	-8.0	-9.6
02-03	-6.9	-21.1	-30.5	-21.4	-18.1	-7.5	-15.3	-5.5	-11.1	-9.8	-18.9	-15.2	-15.1
03-04	-23.6	-11.1	-35.8	-16.7	2.2	-5.6	-14.8	-21.6	-14.0	-21.7	-10.1	-21.5	-16.2
04-05	-21.2	-10.5	-22.5	-5.8	-18.9	-8.9	-20.6	-24.7	-13.7	-17.2	-10.1	-15.0	-15.8
05-06	-12.3	-7.5	-18.9	-5.6	-20.8	-9.5	-14.5	-17.6	-16.1	-9.3	-10.6	-3.7	-12.2
06-07	-11.5	-3.1	-24.6	-6.7	-22.2	-11.1	-10.0	-8.2	-17.7	-3.7	-7.4	1.9	-10.4
07-08	-8.8	-1.4	-15.0	-7.2	-16.4	-11.1	-6.3	-10.0	-17.7	0.5	-6.6	1.6	-8.2
08-09	-9.6	-3.1	-2.2	-7.2	-10.3	-8.3	-5.0	-16.0	-11.9	0.8	-5.6	0.8	-6.5
09-10	-9.9	-3.9	-1.9	-7.0	-12.2	-8.9	-6.9	-13.4	-10.0	-2.6	-7.2	-7.2	-7.6
10-11	-12.9	-7.2	-0.8	-8.1	-11.1	-4.4	-11.9	-13.2	-8.2	-2.9	-9.6	-8.6	-8.2
11-12	-13.7	-6.7	-1.7	-9.7	-9.2	-2.8	-6.6	-7.4	-10.3	-5.0	-9.3	-7.7	-7.5
12-13	-14.0	-3.3	3.6	-2.8	-5.0	-0.9	-4.8	-3.2	1.3	-5.6	-5.6	-8.3	-4.0
13-14	-6.3	0.6	7.8	3.6	1.1	2.5	-2.4	2.4	4.0	-4.8	-0.3	-4.3	0.3
14-15	8.5	8.1	15.6	14.5	17.0	6.4	8.4	15.0	10.6	6.9	8.2	1.1	10.0
15-16	8.5	12.8	18.3	14.5	19.5	7.5	8.2	14.7	11.4	8.7	11.4	4.3	11.6
16-17	11.8	13.9	18.0	13.1	21.4	7.5	8.7	15.3	12.2	7.7	15.2	6.9	12.6
17-18	14.3	13.9	23.0	9.7	21.7	7.8	9.2	14.0	9.8	10.0	15.2	9.6	13.2
18-19	20.3	20.6	21.1	10.6	12.0	8.9	10.8	17.4	10.8	13.7	11.4	21.9	15.0
19-20	25.0	15.3	19.4	18.3	15.8	8.6	12.1	18.4	13.0	13.2	11.7	16.3	15.6
20-21	21.9	15.8	21.1	13.1	16.7	6.1	15.3	16.6	11.6	11.6	14.9	16.0	15.2
21-22	24.4	6.9	21.9	12.5	10.3	8.9	15.0	17.9	17.2	11.6	5.6	16.3	14.0
22-23	13.2	6.4	20.8	9.7	17.5	8.3	15.3	19.7	14.5	7.1	11.2	8.6	12.7
23-24	9.3	-1.4	-6.9	-8.3	9.7	7.0	11.6	8.7	8.2	3.2	7.4	-2.1	3.9

Table 4--Average diurnal variation of magnetic declination shown by departures from monthly mean, College, Alaska, July, 1942, to June, 1943

150° West Meridian Time	Year and month												Mean
	1942						1943						
	July	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	
h h	'	'	'	'	'	'	'	'	'	'	'	'	'
	Departures for all days												
00-01	-4.0	-3.1	-12.1	-4.4	-5.0	1.3	-0.3	-2.1	0.9	-1.4	-2.5	-2.0	-2.9
01-02	-1.0	-2.7	-2.3	7.0	2.1	1.1	2.6	-0.8	1.3	-0.4	-0.3	-1.6	0.4
02-03	-0.2	1.3	1.7	3.6	3.2	6.3	4.3	1.8	3.2	3.6	1.3	1.8	2.7
03-04	1.6	3.2	5.7	2.5	6.7	9.5	2.5	3.9	3.4	5.2	2.8	1.3	4.0
04-05	5.0	5.3	8.0	7.5	7.4	4.9	6.0	3.1	3.3	7.6	6.8	4.5	5.8
05-06	8.3	9.9	10.5	9.1	6.3	3.9	3.1	3.4	5.2	8.8	11.6	8.4	7.4
06-07	11.3	12.1	10.0	8.0	4.5	4.4	4.5	4.9	5.0	8.9	11.1	11.0	8.0
07-08	12.7	10.3	9.1	4.3	3.2	4.3	2.2	4.8	5.1	8.3	9.9	12.2	7.2
08-09	11.2	8.5	5.1	0.3	0.8	0.7	0.7	3.2	5.0	6.7	8.2	10.1	5.0
09-10	7.9	4.1	2.1	0.8	-0.8	-0.8	1.3	0.8	4.4	4.1	5.8	7.4	3.1
10-11	3.1	0.1	-1.4	-3.4	-3.5	-2.7	-0.7	-1.6	1.8	1.5	2.1	2.0	-2.2
11-12	-0.6	-3.7	-3.9	-4.6	-4.1	-4.0	-2.9	-2.3	-1.7	-2.1	-1.8	-0.5	-2.7
12-13	-3.7	-5.5	-4.2	-4.6	-4.7	-4.5	-4.4	-3.0	-3.8	-2.8	-3.9	-3.2	-4.0
13-14	-5.4	-6.6	-5.0	-4.2	-4.8	-4.6	-4.7	-2.8	-4.0	-4.4	-5.2	-5.1	-4.7
14-15	-7.0	-7.1	-3.7	-4.7	-3.2	-4.5	-4.6	-2.6	-3.7	-5.3	-6.2	-7.5	-5.0
15-16	-6.7	-6.3	-3.7	-5.3	-2.7	-3.7	-3.7	-2.2	-5.1	-6.1	-6.1	-7.3	-4.9
16-17	-6.5	-5.9	-3.2	-4.0	-2.4	-2.9	-2.5	-2.6	-4.8	-6.1	-6.2	-6.5	-4.5
17-18	-5.9	-5.5	-2.5	-2.2	-0.8	-2.7	-2.5	-2.8	-3.8	-5.1	-4.7	-6.5	-3.8
18-19	-4.1	-4.0	-1.2	-1.3	-0.3	-1.4	-2.1	-2.4	-3.6	-4.4	-4.6	-3.7	-2.8
19-20	-2.8	-1.0	-0.1	2.7	-0.7	-1.4	-1.2	-1.3	-2.9	-3.0	-2.7	-2.3	-1.5
20-21	-3.1	0.3	-1.4	0.3	2.1	-0.6	1.1	-1.1	-1.0	-3.3	-2.7	-4.7	-1.2
21-22	-3.3	0.2	-1.2	0.5	0.9	0.2	0.6	0.3	-0.7	-3.2	-2.1	-3.5	-0.9
22-23	-3.5	-0.8	-2.8	-3.6	-0.7	1.3	0.9	1.6	-0.7	-4.3	-6.0	-3.9	-1.9
23-24	-3.5	-3.4	-3.4	-4.5	-3.4	-1.7	-0.1	0.1	-2.7	-2.2	-4.3	-3.2	-2.7
	Departures for quiet days												
00-01	-2.4	-2.4	-3.0	-1.8	-1.0	0.3	0.4	-0.7	0.3	-0.3	0.6	-3.4	-1.1
01-02	-1.8	-0.6	1.9	1.2	-1.2	0.6	0.4	1.8	0.2	-0.3	-0.2	-2.2	0.0
02-03	0.2	0.3	4.1	1.0	1.2	0.7	1.3	1.4	1.2	-1.0	0.3	-1.3	0.8
03-04	1.8	1.4	4.6	1.8	3.3	1.1	0.7	1.7	0.5	1.4	0.6	0.3	1.6
04-05	4.8	3.4	6.4	2.6	3.5	0.9	1.4	2.1	0.6	3.0	3.4	2.6	2.9
05-06	7.4	6.1	9.4	3.4	2.0	1.4	1.4	2.5	1.5	4.4	6.6	5.8	4.3
06-07	8.9	7.9	8.4	3.7	2.6	1.7	1.0	2.8	3.3	6.3	8.2	8.2	5.3
07-08	10.9	9.5	5.5	5.1	2.7	1.1	1.3	3.2	5.1	6.5	7.9	10.2	5.8
08-09	11.0	8.7	3.6	4.1	2.7	1.5	2.5	2.2	5.0	6.4	6.8	10.1	4.6
09-10	7.7	5.7	1.8	3.7	1.3	1.1	2.5	1.1	4.7	5.2	5.2	7.8	4.0
10-11	3.0	2.1	-1.0	-0.3	-1.3	0.1	0.4	-0.3	2.8	3.2	2.5	4.8	1.3
11-12	0.1	-2.3	-3.5	-3.7	-2.8	-1.0	-0.8	-1.0	-1.2	-0.9	-0.2	0.8	-1.4
12-13	-4.5	-5.1	-4.5	-4.1	-3.7	-1.5	-2.4	-2.4	-1.9	-2.6	-3.0	-2.8	-3.2
13-14	-5.9	-6.2	-4.6	-4.0	-3.5	-1.9	-3.3	-2.7	-3.0	-4.2	-4.9	-5.1	-4.1
14-15	-6.4	-6.7	-3.9	-3.2	-2.5	-2.1	-2.5	-2.7	-3.1	-5.8	-6.2	-7.2	-4.4
15-16	-6.2	-7.3	-3.9	-2.7	-1.9	-2.2	-2.1	-2.0	-3.2	-5.1	-5.9	-6.5	-4.1
16-17	-6.3	-4.1	-3.2	-2.3	-1.8	-1.7	-1.4	-2.6	-3.8	-4.3	-5.4	-5.5	-3.5
17-18	-5.3	-4.0	-3.1	-2.6	0.3	-1.0	-1.4	-2.3	-3.2	-3.8	-3.4	-5.2	-2.9
18-19	-5.0	-1.2	-3.8	-1.7	-0.6	-0.5	-0.8	-1.3	-2.4	-2.9	-2.8	-2.4	-2.1
19-20	-3.1	-0.2	-3.8	0.2	-0.3	-0.2	0.0	-0.5	-1.8	-1.9	-2.7	-1.7	-1.3
20-21	-3.1	-1.1	-3.1	-0.6	2.7	0.3	0.3	-0.6	-1.3	-1.8	-1.6	-1.9	-1.0
21-22	-1.0	-2.3	-2.5	-1.3	-0.4	0.4	0.6	-0.8	0.0	-1.2	-1.1	-0.5	-0.8
22-23	-1.9	-1.4	-1.9	1.2	-0.7	0.4	0.9	0.9	0.5	-1.4	-2.3	-1.6	-0.6
23-24	-2.3	-1.6	-2.0	-0.3	-0.6	0.8	0.5	0.3	-0.6	-1.4	-2.0	-3.2	-1.0

Table 5--Preliminary monthly mean values of magnetic elements, College, Alaska, July, 1941, to June, 1943

Month	Element							
	Horizontal intensity, H		Vertical intensity, Z		Declination, D			
	All days	Quiet days	All days	Quiet days	All days		Quiet days	
1941	γ	γ	γ	γ	°	'	°	'
July	12508	.....	+55373	......	+29	36.9	...	....
Aug.	12557	12595	+55319	+55319	+29	54.5	+29	54.9
Sep.	12538	12575	+55367	+55357	+29	55.4	+29	55.9
Oct.	12566	12587	+55367	+55373	+29	54.7	+29	54.5
Nov.	12567	12613	+55365	+55375	+29	52.6	+29	52.6
Dec.	12582	12584	+55360	+55358	+29	52.8	+29	53.2
1942								
Jan.	12591	12602	+55341	+55347	+29	53.8	+29	53.3
Feb.	12584	12603	+55324	+55323	+29	53.1	+29	53.2
Mar.	12570	12604	+55328	+55335	+29	52.6	+29	52.7
Apr.	12577	12606	+55356	+55359	+29	51.5	+29	51.1
May	12616	12620	+55313	+55314	+29	49.1	+29	49.3
June	12606	12618	+55339	+55350	+29	51.4	+29	51.9
July	12598	12612	+55383	+55376	+29	51.6	+29	52.2
Aug.	12589	12608	+55332	+55339	+29	52.1	+29	52.3
Sep.	12570	12620	+55341	+55343	+29	51.7	+29	52.6
Oct.	12540	12599	+55291	+55301	+29	52.7	+29	52.6
Nov.	12569	12596	+55378	+55398	+29	52.5	+29	52.1
Dec.	12570	12601	+55385	+55383	+29	52.4	+29	51.2
1943								
Jan.	12566	12593	+55381	+55386	+29	51.7	+29	50.6
Feb.	12595	12604	+55361	+55366	+29	49.4	+29	50.1
Mar.	12585	12610	+55348	+55356	+29	49.4	+29	49.8
Apr.	12587	12604	+55348	+55360	+29	49.3	+29	49.9
May	12588	12608	+55331	+55343	+29	50.0	+29	50.2
June	12602	12617	+55300	+55308	+29	48.2	+29	48.1

Fig. 1--Mount Wilson Observatory, showing dome of 60-inch reflector and 60-foot and 150-foot tower telescopes

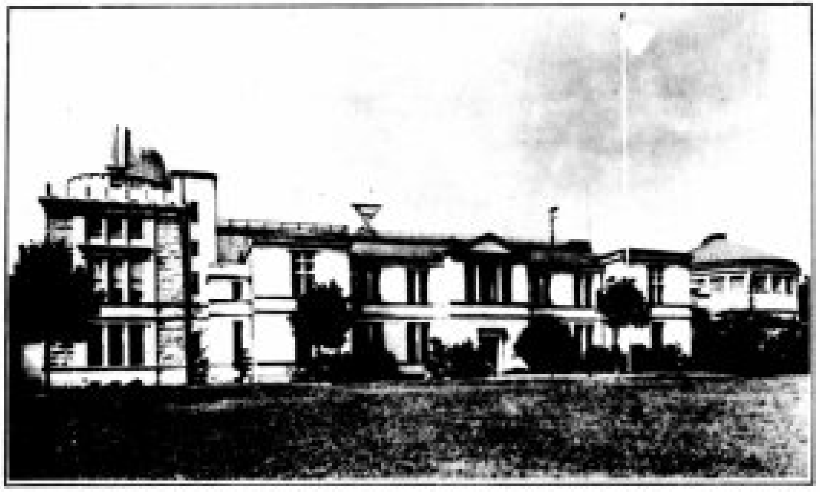

Fig. 2--The United States Naval Observatory

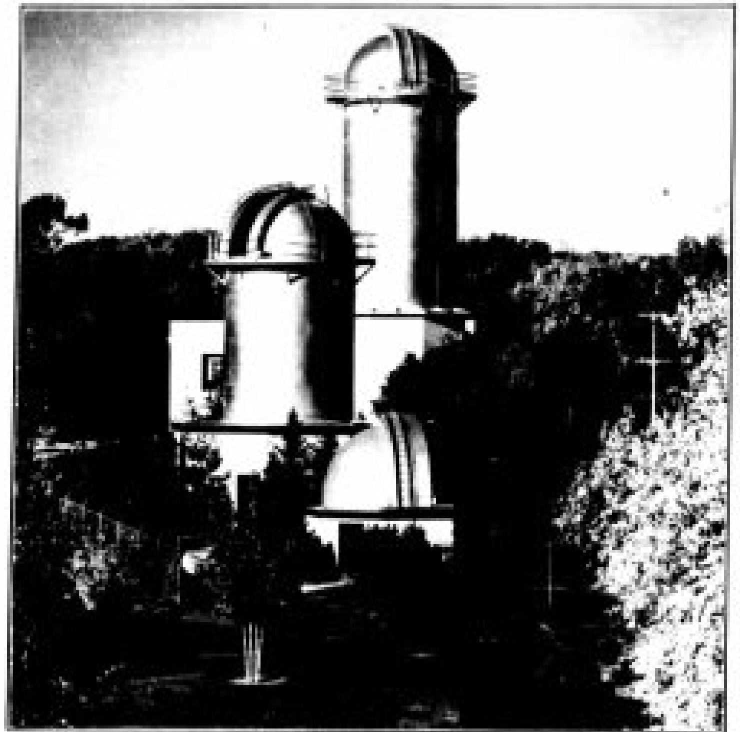

Fig. 3--The McMath-Hulbert Observatory of the University of Michigan, showing 50-foot and 70-foot tower telescopes

Fig. 4--Climax (Colorado) Station of Harvard College Observatory, showing dome of coronograph

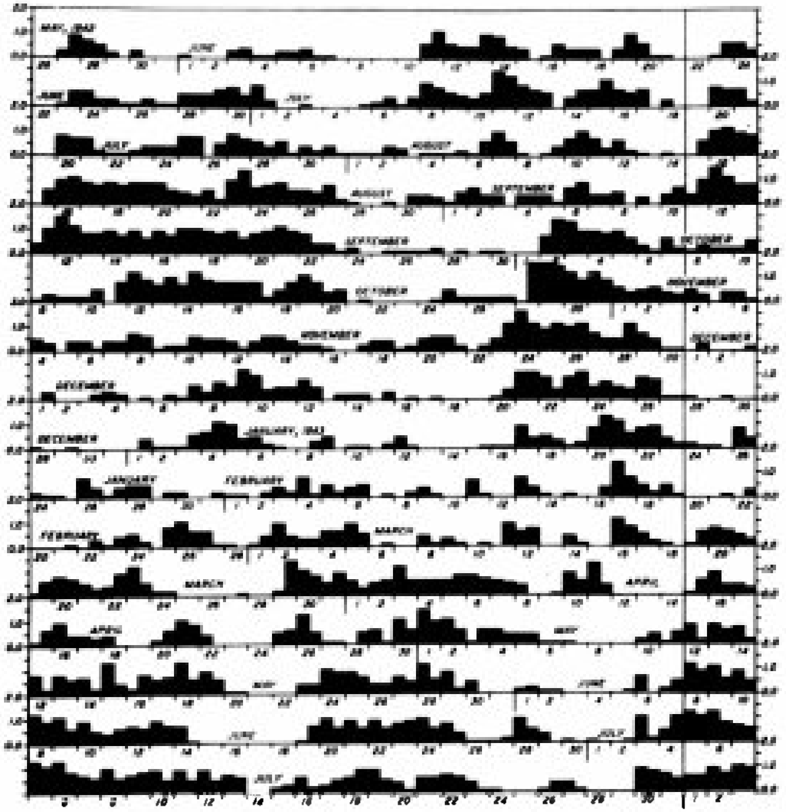

Fig. 5--Recurrence-tendencies of magnetic activity in half-days at 27-day intervals

Fig. 6--American magnetic character-figure (C_A), relative sunspot-number (R), spot-area in central zone (S), floccular area in central zone (F), average intal prominence-units referred to central meridian of date (P), average coronal intensity referred to central meridian of date (C), and transmission-disturbance figures (TD), July 1, 1942, to July 10, 1943

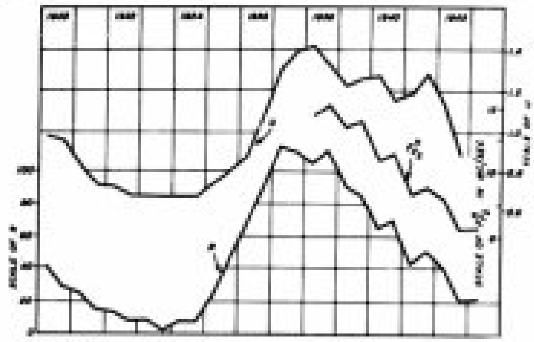

Fig. 7--Semi-annual averages of magnetic index (u), relative sunspot-number (R), 1930-43, and maximum critical frequency of F_2-layer, 1936-43, at Huancayo, Peru

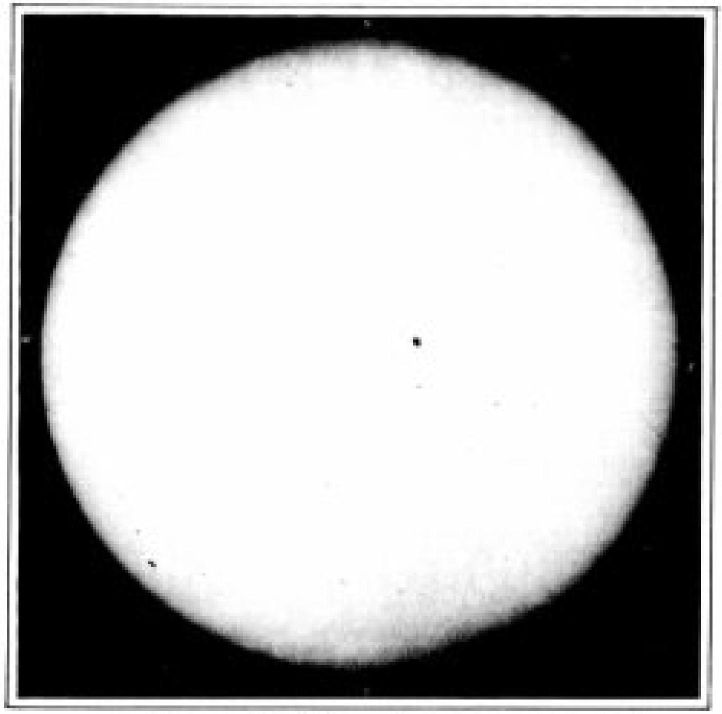

Fig. 8--Photograph of Sun on May 17, 1943, showing first spot in new sunspot-cycle (lower left) and spot of old cycle (center)
[Courtesy of United States Naval Observatory]

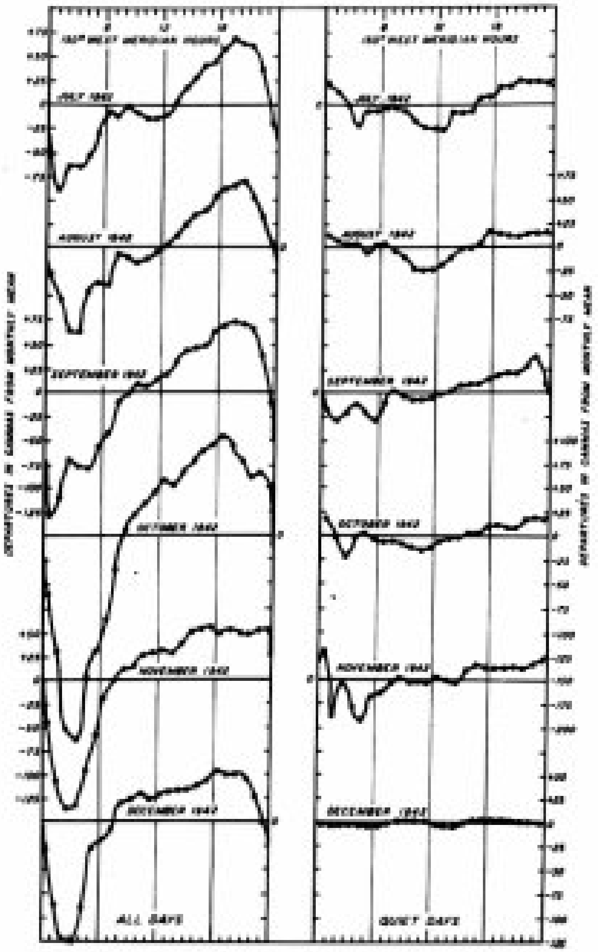

Fig. 15A--Average diurnal variation in horizontal intensity, College, Alaska, July to December, 1942

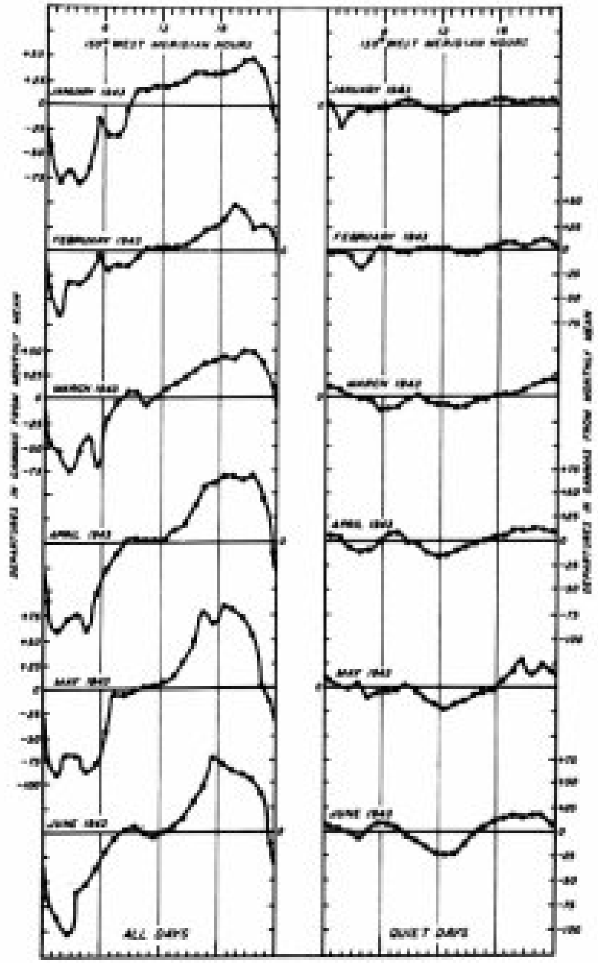

Fig. 15B--Average diurnal variation in horizontal intensity, College, Alaska, January to June, 1943

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Correlation of Solar and Geomagnetic Observations with Conditions of the Ionosph phere, Final Report on Project C-53, July, 1942 through June, 1943 (None)

Shapley, A. H.; Wells, H. W.

Carnegie Inst. of Wash., Dept. of Terrestrial Magnetism (None)

Office of Scientific Research and Development, NDRC, Div 13 (

OSRD-1890

Sept '43 Restr. U.S. Eng. 25 photos, table, graphs

A study was made of the correlation of solar and geomagnetic observations with conditions of the ionosphere, during July 1942 through June 1943, to gain information regarding solar, geomagnetic, and ionospheric relationships and to improve the technique of short-term forecasting of ionospheric disturbances. Electron-density of the ionospheric regions affecting long-distance radio communication diminished as the minimum of the 11-year cycle of activity approached. Solar corona of high intensity, and observed activity of flocculi on the disk were found apparently the most promising criteria for anticipation of magnetic disturbances. The beginning of the new sunspot-cycle indicates an early increase of solar, magnetic, and ionospheric activity.

Copies of this report obtainable from Air Documents Division; Attn: MCIDXD

Electronics (3) Electromagnetic disturbances (31507.14);

Static and Interference (4) Wave propagation, Ionospheric (97999.5)

R-3-4